Metric Report Summary

CCMC compared predicted ground magnetic perturbations of two models with ground magnetometer data from the Greenland chain. The two models were the Weimer 2K Electric Potential Model and the Weimer Magnetic Potential Model. The Weimer 2K Electric Potential Model was run using four different Hall conductivities. The Weimer Magnetic Potential Model requires a ratio of the Pedersen to Hall Conductivity. This was set at 1.5 as suggested by Dr. Weimer. This test was done for six days. Five of the days were quiet days with a minimum DST between –4 and –41. One day was a storm day. All models were run for four different delay times. All models were also run using both real-time ACE data received from NOAA Space Environment Center and level 2 data from the ACE web site. Ten stations from the Greenland chain were used for comparison of the H-component of the magnetic field. For each day, an average skill score of the ten stations was calculated. The details of the procedures are included in a separate document. For each model, time delay, and input data, we calculated an average skill score for the six days. The table with the results is included as a separate document.

We found that the skill scores for Level 2 ACE data was significantly higher than for real-time ACE data. For Level 2 ACE data, we found that the Weimer 2K Electric Potential Model using a Hall conductivity of 7.5 mhos gave the best results. For real-time ACE data, we found that the Weimer 2K Electric Potential Model using a Hall conductivity of 5.0 mhos gave the best results. The difference in skill scores between a Hall conductivity of 5.0 mhos and 7.5 mhos was very small. We ran using four time delays. In three cases, the solar wind was propagated from ACE to a magnetopause of 10 R_E using an instantaneous velocity then an additional time delay was included. The three time delays were 14, 30 and 45 minutes. We also ran cases where the solar wind was propagated from ACE to the Earth. There was not a significant difference in skill scores for the different time delays but the best results occurred with a time delay of 30 minutes from the magnetopause.

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Model and Version	Time Delay	Conductivity Model	Level of Input Data	Avg Of Skill Score	Min Of Skill Score	Max Of Skill Score
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 10.0	Level 2	0.20	0.07	0.36
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 10.0	Real-time	0.10	-0.11	0.30
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 12.5	Level 2	0.10	-0.01	0.27
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 12.5	Real-time	-0.01	-0.39	0.24
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 5.0	Level 2	0.24	0.13	0.35
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 5.0	Real-time	0.18	0.09	0.31
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 7.5	Level 2	0.25	0.11	0.39
Weimer 2K Electric Potential	Propagated to 10 Re then 14 min delay	Constant Hall Conductivity 7.5	Real-time	0.17	0.07	0.34
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 10.0	Level 2	0.21	0.02	0.38
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 10.0	Real-time	0.11	-0.08	0.32
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 12.5	Level 2	0.10	-0.05	0.28
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 12.5	Real-time	0.00	-0.35	0.25
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 5.0	Level 2	0.25	0.10	0.36
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 5.0	Real-time	0.18	0.07	0.31
Weimer 2K Electric Potential	Propagated to 10 Re then 30 min delay	Constant Hall Conductivity 7.5	Level 2	0.26	0.08	0.41
Weimer 2K Electric	Propagated to 10 Re then 30 min	Constant Hall Conductivity 7.5	Real-time	0.17	0.03	0.34

Model and Version	Time Delay	Conductivity Model	Level of Input Data	Avg Of Skill Score	Min Of Skill Score	Max Of Skill Score
Potential	delay					
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 10.0	Level 2	0.20	-0.01	0.38
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 10.0	Real-time	0.11	-0.08	0.31
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 12.5	Level 2	0.09	-0.09	0.27
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 12.5	Real-time	0.01	-0.33	0.24
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 5.0	Level 2	0.24	0.08	0.35
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 5.0	Real-time	0.18	0.05	0.30
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 7.5	Level 2	0.25	0.05	0.41
Weimer 2K Electric Potential	Propagated to 10 Re then 45 min delay	Constant Hall Conductivity 7.5	Real-time	0.17	0.00	0.33
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 10.0	Level 2	0.18	0.03	0.34
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 10.0	Real-time	0.08	-0.13	0.30
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 12.5	Level 2	0.08	-0.05	0.25
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 12.5	Real-time	-0.03	-0.41	0.23
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 5.0	Level 2	0.23	0.11	0.33
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 5.0	Real-time	0.17	0.07	0.31
Weimer 2K Electric Potential	Propagated to Earth	Constant Hall Conductivity 7.5	Level 2	0.24	0.09	0.38
Weimer 2K Electric	Propagated to Earth	Constant Hall Conductivity 7.5	Real-time	0.15	0.02	0.33

Model and Version	Time Delay	Conductivity Model	Level of Input Data	Avg Of Skill Score	Min Of Skill Score	Max Of Skill Score
Potential						
Weimer Magnetic Potential Model	Propagated to 10 Re then 14 min delay	Constant Pedersen to Hall Conductivity Ratio 1.5	Level 2	0.17	-0.07	0.33
Weimer Magnetic Potential Model	Propagated to 10 Re then 14 min delay	Constant Pedersen to Hall Conductivity Ratio 1.5	Real-time	0.04	-0.18	0.29
Weimer Magnetic Potential Model	Propagated to 10 Re then 30 min delay	Constant Pedersen to Hall Conductivity Ratio 1.5	Level 2	0.18	-0.10	0.33
Weimer Magnetic Potential Model	Propagated to 10 Re then 30 min delay	Constant Pedersen to Hall Conductivity Ratio 1.5	Real-time	0.05	-0.16	0.31
Weimer Magnetic Potential Model	Propagated to 10 Re then 45 min delay	Constant Pedersen to Hall Conductivity Ratio 1.5	Level 2	0.17	-0.13	0.33
Weimer Magnetic Potential Model	Propagated to 10 Re then 45 min delay	Constant Pedersen to Hall Conductivity Ratio 1.5	Real-time	0.05	-0.16	0.30
Weimer Magnetic Potential Model	Propagated to Earth	Constant Pedersen to Hall Conductivity Ratio 1.5	Level 2	0.16	-0.08	0.33
Weimer Magnetic Potential Model	Propagated to Earth	Constant Pedersen to Hall Conductivity Ratio 1.5	Real-time	0.02	-0.18	0.29

Metric procedure:

A. Preparation of IMF input file
  I. Level 2 data:
      1.) Level 2 data for magnetic field in GSM coordinates including x position of spacecraft in km is downloaded from the ACE web site. This data is in 4-minute averages.
      2.) Level 2 data from plasma instrument, proton density, proton temperature, vx (gsm), vy (gsm), vz (gsm) is downloaded from the ACE web site. This data is 64 second.
      3.) Bad or missing data points that were marked in file are removed.
      4.) An idl routine is run that does the following:
          a). Interpolates the plasma data to the 4 minute average for magnetic field.
          b.) Calculates a time shift from ACE.   For the metric report, four time shifts were used. The 14-min delay was [(xpos – 10 Re)/vx] +14 min. The 30-min delay was [(xpos – 10 Re)/vx] +30 min. The 45-min delay was [(xpos – 10 Re)/vx] +45 min The fourth time shift was [xpos /vx]. An instantaneous vx is used at each time step. There is no time averaging.
          c.) Eliminates points that have been overtaken.
          d.) Writes IMF.dat file
  II. Real-time data:
      1.) Both magnetic field and plasma data were in 1-minute averages.
      2.) Bad or missing data points that were marked in file are removed.
      3.) An idl routine is run that does the following:
          a). Interpolates the plasma data to the 1 minute average for magnetic field.
          b.) Calculates a time shift from ACE.   For the metric report, four time shifts were used. The 14-min delay was [(xpos – 10 Re)/vx] +14 min. The 30-min delay was [(xpos – 10 Re)/vx] +30 min. The 45-min delay was [(xpos – 10 Re)/vx] +45 min The fourth time shift was [xpos /vx]. Since the real-time data files from SEC did not have the x position of the satellite in the files, I used the x position from the level 2 data. An instantaneous vx is used at each time step. There is no time averaging.
          c.) Eliminates points that have been overtaken.
          d.) Writes an IMF.dat file
      4.) Every fourth point is used in the metric calculation.

B. Computation of ground magnetic field perturbations:
      1.) Use run_all_IMFtimes.pl to read IMF.dat and run the idl integration routine.
      2.) Idl integration routine integrates on a sphere using the Biot-Savart law. The coordinates run from 51 to 89 degrees in latitude and 360 degrees in longitude. The grid size is 1 degree in both latitude and longitude.
      3.) The geographic coordinates are converted to CGM coordinates to calculate an electric potential in Weimer's 2K potential routine at 110 km altitude. Using electric potential, the electric field is calculated in spherical coordinates.
      4.)

a.) The Hall current is calculated by $j_H = \Sigma_H \mathbf{e}_r \times \mathbf{E}$ where the magnetic field is assumed to be in the $\mathbf{e}_r$ direction and the conductivity is constant.

b.) The Hall current can also be computed using magnetic Euler potentials. In this case the field-aligned currents are calculated using measurements of the magnetic perturbations in orbits. The magnetic Euler potentials can then be used to calculate the Hall current.

5.) The Hall current is converted in Cartesian coordinates for the integration.

6.) The integration is only done on a circle that contains all the points within the horizon.

$$\text{Maxangle} = \text{acos}(RE/(re+110km))$$
$$\text{Maxdist} = \sin(\text{maxangle}) \times (re+110km)$$

7.) After integration, the magnetic perturbations are converted into spherical coordinates then into the coordinate system used by the ground magnetometers. The conversion is done with the 2001 declination angles for each station.

C. Computation of skill scores:

1.) Bad data points from Greenland data are removed.

2.) The simulation data is interpolated to the time period of the Greenland data which is 20 seconds. If there is more than a five minute gap in the simulation data, that time period gap is eliminated in the metric comparison.

b.) An individual model is scored using $D_i = (\Sigma| \Delta H \text{(model)} - \Delta H \text{(data)}|)/npts$ over all the points where npts is the total number of points.

c.) The metric is then $M_i = 1 - D_i/D_t$ where D_t is the standard test model. The standard test model is $\Delta H \text{(model)} = 0$. The standard model uses the same time sample as D_i.

d.) The metric is scored for ten stations. The scores from the ten stations are averaged to get a score for a day.